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The Miners Friend;
OR, AN
ENGINE
TO RAISE
WATER
BY
FIRE,
DESCRIBED.

AND
Of the manner of Fixing it in
MINES.

WITH
An Account of the ſeveral other Uſes it
is applicable unto; and an
ANSWER
To the OBJECTIONS made againſt it.

By *THO. SAVERY* Gent.

*Pigri eſt ingenii contentum eſſe his, quæ ab
aliis inventa ſunt.* Seneca.

LONDON: Printed for *S.Crouch* at the Corner of
Popes-Head-Alley in *Cornhil.* 1702.

G.R. III
BR. MUS.

TO THE

KING.

SIR,

YOUR *Majeſty having been graciouſly pleaſed to permit an Experiment before you at* Hampton-Court *of a ſmall Moddle of my Engine deſcribed in the following Treatiſe, and at that time to ſhew a* *ſeeming Satisfaction of the Power and Uſe of it: And having moſt graciouſly enabled me by your Royal Aſſent to a Patent and Act of Parliament to perſue and perfect the ſame. By which your Royal Incouragement, it being now fully Compleated, and put in Practice in your Dominions, with that repeated Succeſs and Applauſe: That it is not to be doubted but it will be of Univerſal Benefit and Uſe to all your Majeſties Subjects. Of whom your Majeſty being the Univer-*

ſal Patron and Father, all Arts and Inventions that may promote their Good and Advantage, ſeem to lay a juſt and natural Claim to your Majeſties Sacred Protection.

'Tis upon this Conſideration I am incouraged with a profound Reſpect to throw this Performance of mine, with the Author, at your Majeſties Royal Feet, moſt humbly beſeeching your Majeſty, That as it had Birth in your Majeſties Auſpicious Reign, You will vouchſafe to

perpetuate it to future Ages by the Sanction of your Royal Approbation, which is the utmoſt Ambition of,

May it pleaſe your Majeſty,

Your Majeſties

moſt Humble,

moſt Loyal,

and moſt Obedient

Subject,

Tho. Savery.

TO THE

Royal Society.

AT the Requeſt of ſome of your Members at the Weekly Meeting at *Greſham-Colledge*, *June* the 14th 1699. I had the honour to work a ſmall Moddle of my Engine before you, and you were pleaſed to approve of it. Since which I have met with great Difficulties and Expence, to inſtruct Handicraft Artificers to forme my Engine according to my Deſign; but my Workmen, after ſo much Experience, are become ſuch Maſters of the thing, that they oblige themſelves to deliver what Engines they make me, exactly tight and fit for Service, and as ſuch I dare warrant them to any Body that has occaſion for them.

Your kindneſs in countenancing this Invention in its firſt Appearance in the World, gives me hopes the Uſefulneſs of it will make it more acceptable to your Honourable SOCIETY, as they are the moſt proper Judges of what Advantage it may be to Mankind. And it would be ungrateful in me not to make uſe of this Opportunity to return you my moſt humble and hearty Thanks for the Honour and Favour you did me in Approving my Deſign, and * publiſhing it to the World; which ſhall be always acknowledged by

Your moſt obliged
and moſt humble
Servant

Tho. Savery.

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* Philoſoph. Tranſact. Numb. 252.

TO THE
Gentlemen Adventurers
IN THE
Mines of ENGLAND.

I Am very ſenſible a great many among you do as yet look on my *Invention* of raiſing *Water* by the impellent force of *Fire*, a uſeleſs ſort of a *Project*, that never can anſwer my *Deſigns* or *Pretenſions*; and that it is altogether impoſſible that ſuch an *Engine* as this can be wrought *under-ground*, and ſucceed in the

Raiſing of *Water*, and *Dreining* your *Mines*, ſo as to deſerve any Incouragement from you. I am not very fond of lying under the *Scandal* of a bare *Projector*, and therefore preſent you here with a *Draught* of my *Machine*, and lay before you the Uſes of it, and leave it to your Conſideration, whether it be worth your while to make uſe of it or no. I can eaſily give grains of allowance for your *Suſpicions*, becauſe I know very well what *Miſcarriages* there have been by People *Ignorant* of what they *pretend* to. Theſe I know have been ſo *frequent*, ſo fair and *promiſing at firſt*, but ſo ſhort of *performing* what they pretended to, that your *Prudence* and *Diſcretion* will not now ſufſer you to *believe* any thing without a demonſtration, your Appetites to *new Inventions* of this nature, having been *baulkt* too often; yet after all, I muſt beg you not to *condemn* me, before you have *read* what I have to *ſay* for my *ſelf*, and let not the *failures* of *others* prejudice me, or be placed to my account. I have often lamented the want of underſtanding the true *Powers of Nature*, which misfortune, has of late put ſome on making ſuch vaſt *Engines* and *Machines*, both *trouble-ſome* and *expenſive*, yet of *no* manner of *uſe*, inaſmuch as the *old Engines*, uſed many *Ages* paſt, far exceeded them. And I fear, whoever by the *old Cauſes* of Motion pretends to *Improvements* within this *laſt Century*, does *betray* his *Knowledge* and Judgment. For more then an hundred years ſince, *Men* and *Horſes* would Raiſe by *Engines* then made, as much *Water* as they have ever ſince done, or I believe ever will, or according to the *Law of Nature* ever can do. And though my *Thoughts* have been long imployed about *Water-works*, I ſhould never have pretended to any *Invention* of that kind, had I not *happily* found out this *new*, but yet a much *Stronger* and *Cheaper Force* or Cauſe of Motion, than any before made uſe of. But finding this of *Rarefaction by Fire*, the conſideration of the Difficulties the *Miners* and *Colliers* labour under by the frequent *Diſ-*

orders , Cumberſomneſs , and in general of *Water-Engines* ; Incouraged me to *invent* Engines *to work* by this *new force*, that tho' I was obliged to *incounter* the *oddeſt* and almoſt *inſuperable* Difficulties ; I ſpared neither *Time*, *Pains* nor *Money*, till I had abſolutely *Conquer'd them*. I hope this will at leaſt incourage you to *read* over this *ſmall Treatiſe* I now put into your hands, for the farther and more particular Information of the *Nature* and *Uſes* of this *Engine* for raiſing *Water* by the *Force of Fire* : After which I ſhall patiently *ſubmit* to any *Judgment* you ſhall pleaſe to *paſs* upon *me* or the *Invention* , and may have reaſon to believe you will not any longer ſuffer your *Judgments* to be impoſed on by *thoſe*, whoſe *Profit* and *Intereſt* it may ſeem to be, to *Condemn* both right or wrong ; I mean *ſuch* who make your common Ginns , and their Friends and Acquaintance among you; tho' I am very ſure the promotion of the *Uſe* of this *Engine* is their true Intereſt, as I very plainly prove thus :

The cheaper *Water* is drawn, the more is the *Miner* incouraged to adventure ; the more the *Miner* adventures, the more *Pits* or *Shafts* muſt be *ſunk* ; the more *Shafts* or *Pits* are ſunk, the more *Wood-work* will be neceſſarily imployed in *Timbering them* , or ſupporting the ſides from *falling* in where the *Earth* is looſe ; beſides *Windeleſſes* and all other *Utenſils* of Wood *uſed* in *Mines*, or the *Trades* depending *thereon* muſt be more, which by increaſing the *Carpenters Trade* in general, will make them ſufficient *amends* for the *loſs* of a ſmall part of that Branch of their *Trade*, called *Ginn-making*. As for *Pump-making*, that part of the *Trade* will be much *Improved* by my *Engine*. For I muſt uſe Board and Timber for *Pipes*; and have conſiderable Imployment for *Pump-makers* and *Carpenters* for Timber uſed about my *Engine*. But ſhall never *Imploy* any other *Perſon* in making *Pipes*, or any other Carpenters work I ſhall have to do, but the *Perſon* who was before *imployed* in the *Work*, or ſuch as ſhall be recommended, as a *Perſon* imployed in the *Mines* of the *Country* whereſoever I ſhall fix *Engines*; provided they will work as cheap, and fairly, and obſerve the Orders and Directions given them. For my *Deſign* is not in the leaſt to *prejudice* the *Artificers*, or indeed any *other* ſort of *People*, by this *Invention*; but on the contrary, is intended for the *Benefit* and *Advantage* of *Mankind* in general, eſpecially the *People* of my own *Nation*; and wherein, you *Gentlemen* concern'd in *Mines*, may, if you pleaſe, *Reap* the greateſt *Profit*.

And altho' I do not queſtion but the *Plan*, and *Draught* of my *Engine*, will be very well and readily underſtood with *many* Gentlemen, by the *Deſcription* here given; yet it will require a longer Time in *Others*, to imploy their Minds and Thoughts more Intenſely about it; eſpecially ſuch as have not been *familiar* and acquainted with *things* of this *kind*. But ſhould the *Engine*, to the Apprehenſion of ſome, ſeem *intricate* and difficult to be worked, after all the *Deſcription* I have given of it in this *Book*; yet I can, and do aſſure them, That the *attending* and working the *Engine* is ſo far from being ſo, that it is familiar and *eaſie* to be learned by thoſe of the *meaneſt Capacity*, in a very little time; inſomuch, that I have Boys of 13 or 14 years of

Age, who now *attend* and *work it* to perfection, and were *taught* to do it in a few days; and I have known ſome *learn* to work the Engine in *half an hour*. We have a Proverb, That *Intereſt* never lyes: And I am aſſured that you *Gentlemen* of the *Mines* and *Collyeries*, when you have once made this *Engine* familiar in your Works, and to your Selves and Servants; not only the *Profit*, but abundance of other *Advantages* and Conveniencies, which you will find to attend your Works in the *Uſe* thereof, will create in you a favourable Opinion of the Labours of

Your real Friend

and humble Servant

Tho. Savery.

London, Sept. 22.
1701.

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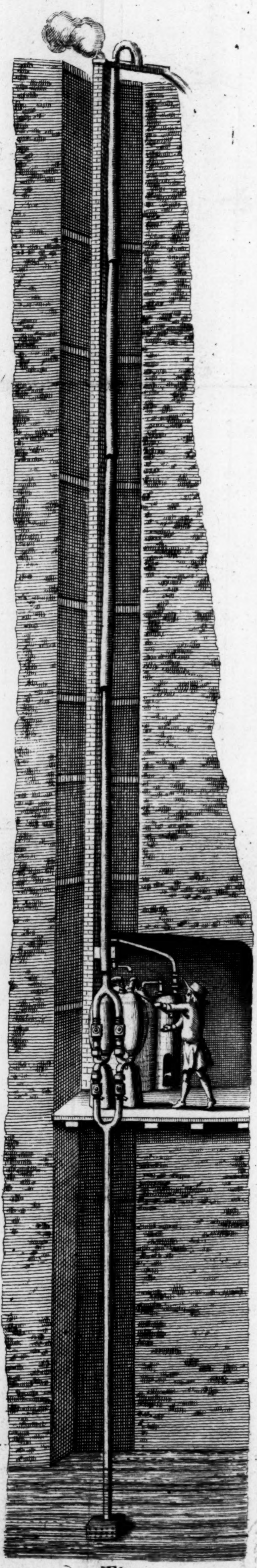
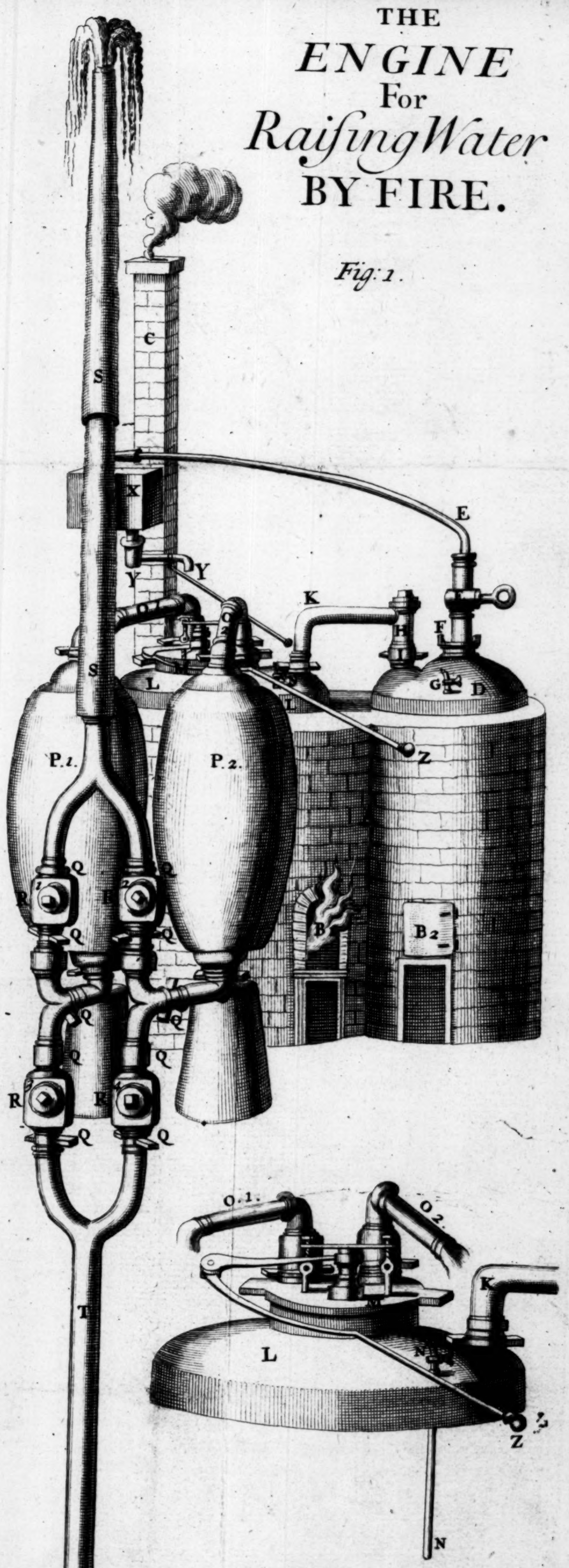
Fig: 2.



The
ENGINE
Working in a
MINE.

THE ENGINE For Raiſing Water BY FIRE.

Fig: 1.



B. Lens delin: I. Sturt ſculp:

A Deſcription of the Draught *of* THE ENGINE, *for raiſing Water by Fire.*

A. The Furnaces.

B.B. The two *Fire* places.

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C. The Funnel or Chimney.

D. The *ſmall* Boyler.

E. The Pipe and Cock of it.

F. The Skrew that Covers and Confines its Force.

G. a ſmall Cock a Pipe going within Eight Inches of its Bottom.

H. a larger Pipe going the ſame Depth.

I. a Clack on the top of the ſaid Pipe.

K. a Pipe going from the Box of

the ſaid Clack or Valve, into the *great* Boyler, about an Inch into it.

L. The great *Boyler.*

M. The *Skrew* with the *Regulator.*

N. a ſmall Cock and Pipe going half way down the great *Boyler.*

O.O. 1.2 Steam-Pipes,one end of each Skrew to the *Regulator*, and the other ends to the *Receivers.*

P.P. 1.2 The Veſſels called *Receivers.*

Q. The Skrews which bring on the Pipes and Clacks in the Front of the *Engine.*

R.R.R.R N° 1. 2. 3. 4. *Valves* or Clack of *Braſs*, with Skrews to open and come at them upon occaſion.

S. The Force-Pipe.

T. The Sucking-Pipe.

V. a ſquare Frame of *Wood*, with *Holes* round its Bottom in the *Water*.

X a *Ciſtern* with a Buy-Cock coming from the Force-Pipe.

Y. a Cock and Pipe coming from the bottom of the ſaid Ciſtern.

Z. The *Handle* of the Regulator.

CHAP. I.

The manner of Working the Engine.

THE firſt thing is to *fix* the *Engine* in a good *Double Furnace*, ſo contrived that the *Flame* of your *Fire* may Circulate round, and Incompaſs your two *Boylers* to the beſt advantage, as you do Coppers for brewing. Before you make any *Fire*, unskrew *G* and *N*, being the two ſmall *Gauge* Pipes and *Cocks* belonging to the two *Boylers*. And at the holes fill *L* the *Great Boyler* two thirds *full* of *Water*, and *D* the *Small Boyler* quite full. Then *ſkrew* in the ſaid *Pipes* again as faſt and *tight* as poſſible. Then *Light* the *Fire* at *B* N° 1. When the *Water* in L *boyls*, the *Handle* of the *Regulator* mark'd *Z*, muſt be *thruſt* from you as *far* as 'twill go, which makes all the *Steam* riſing from the *Water* in L, *paſs* with irriſiſtible *Force* through *O* N° 1. into *P* N 1. *puſhing* out all the *Air* before it, through the *Clack* R N° 1. making a *Noiſe* as it goes. And when all is gone *out*, the *Bottom* of the Veſſel *P* N° 1. will be very *hot*. Then pull the *Handle* of the *Regulator* to you, by which means you *ſtop O* N° (1.) and *force* your *Steam* through *O* N° 2. into the *P* N° 2. until that

Veſſel has diſcharg'd its *Air* through the *Clack R* N° 2. up the force Pipe. In the mean time, by the *Steams condenſing* in the Veſſel *P* N° (1.) a *Vacuum* or Emptineſs is created. So that the *Water* muſt and will neceſſarily *Riſe* up through *T* the *ſucking Pipe*, liſting up the *Clack R* N° (3.) and filling the Veſſel *P* N° 1.

In the mean time the *Veſſel P* N° (2.) being *Emptied* of its *Air*; turn the Handle of the *Regulator* from you again, and the *Force* is upon the *Surface* of the *Water* in *P* N° (1.) which *Surface* being only *heated* by the *Steam*, it does not *condenſe* it, but the *Steam* Gravitates or *Preſſes* with an *Elaſtick Quality* like Air;

Air ; ſtill increaſing its Elaſticity or *Spring*, till it *Counterpoiſes*, or rather Exceeds the *Weight* of the *Water* aſcending in *S*, the *Forcing* Pipe Out of which the *Water* in *P* N° (1.) will be immediately *diſcharged* when once gotten to the top, which takes up ſome time to Recover that power ; which having once got, and being in work, it is *eaſie* for *any* one that never ſaw the *Engine*, after half an hours Experience, to *keep* a conſtant *Stream*, running out the *full Bore* of the Pipe *S*. For on the *out-ſide* of the *Veſſel P* N° (1). you may *ſee* how the *Water goes out*, as well as if the *Veſſel* were *Tranſparent*. For as far as the *Steam continues* within the *Veſſel*, ſo far is the

Veſſel dry without, and ſo very *hot*, as ſcarce to *endure* the leaſt touch of the *Hand.* But as far as the *Water* is, the ſaid *Veſſel* will be *cold* and wet, where any *Water* has faln on it; which *cold* and moiſture *vaniſhes* as faſt as the *Steam*, in its *Deſcent*, takes place of the *Water*. But if you *force* all the *Water* out, the *Steam*, or a ſmall part thereof, going through *R* N° (1.) will *rattle* the *Clack*, ſo as to give ſufficient notice to *pull* the *Handle* of the Regulator *to you*; which at the ſame time begins to *force* out the *Water* from *P* N° (2.) without the leaſt alteration of the *Stream*; only ſome times the Stream of *Water* will be ſomewhat ſtronger than before. If you *pull* the *Handle* of the *Regulator*, before any conſiderable quantity of *Steam* be *gone up* the *Clack R* N° (1.). But it is much better to let none of the *Steam* go off, (for that is but loſing ſo much ſtrength) and is eaſily prevented, by *pulling* the *Regulator* ſome *little time* before the *Veſſel* forcing is quite *emptied*. This being done, immediately *turn* the *Cock* or Pipe of the *Ciſtern* X on *P* N° (1.) ſo that the *Water* proceeding from from X through *Y* (which is never open, but when *Turned* on *P* N° (1.) or *P* N° 2. but when between them, is tight and ſtanch) I ſay, the *Water* falling on *P* N° (1.) cauſes by its *Coolneſs* the *Steam* (which had ſuch great *force* juſt before) to its Elaſtick power, to *Condence*, and become a *Vacuum*, or empty Space. So that the *Veſſel P* N° (1.) is by the *External* Preſſure of the *Atmoſphere*, or what is vulgarly called *Suction*, immediately *Refilled*, while *P* N° (2.) is *emptying*; which being done, you puſh the Handle of the *Regulator* from you, and throw the *Force* on *P* N° (1.) pulling the *Condenſing Pipe* over *P* N° 2. cauſing the *Steam* in that *Veſſel* to *Condenſe*, ſo that it *Fills* while the other *Empties*. The labour of *Turning* theſe *two* parts of the Engine, *viz.* the *Regulator* and *Water-Cock*, and Tending the *Fire*, being no more than what a *Boys* ſtrength can perform for a *day* together, and is as eaſily learn'd as their driving of a *Horſe* in a *Tub-Gin* : Yet, after all, I would have *Men*, and thoſe too the moſt apprehenſive, imployed in working of the *Engine*, ſuppoſing them more careful than *Boys.* The difference of this Charge is not to be mention'd, or accounted of, when we conſider the vaſt *Profit* which thoſe who uſe the *Engine* will Reap by it.

The Ingenious *Reader* will probably here *Object*, That the *Steam* being the Cauſe of this Motion and Force, and that *Steam* is but Water *Rarified*, the *Boyler L* muſt in ſome certain time be *emptied*, ſo as the work of the *Engine* muſt *ſtop* to *repleniſh* the *Boyler*, or indanger the *Burning* out, or *Melting* the bottom of the *Boyler*.

To *Anſwer* which, pleaſe to obſerve the Uſe of the *ſmall Boyler* D. When it is thought fit by the *Perſon* tending the Engine to *Repleniſh* the *great Boyler* (which requires an hour and half, or *two hours* time to the ſinking *one foot* of Water) then, I ſay, by *turning* the Cock of the *ſmall Boyler* E, you *cut off* all Communication between *S* the *great Force-Pipe*, and *D* the *ſmall Boyler*, by which means *D* grows immediately *hot*, by throwing a little *Fire* into *B* N 2. and the *Water* of which boyls, and in a very little time it gains more ſtrength than the *great Boyler*. For the *Force* of the *great Boyler* being perpetually *ſpending* and going out, and the other winding up, or *increaſing*, it is not long before the *Force* in *D* exceeds that in *L*; ſo that the Water in *D*, being Depreſt in *D* by its own *Steam* or *Vapour*, muſt neceſſarily *Riſe* through the *Pipe H*, Opening the *Clack I*, and ſo go through the *Pipe K* into *L*, Running till the *Surface* of the Water in *D* is *equal* to the *bottom* of the *Pipe H*. Then *Steam* and *Water* going together, will by a *Noiſe* in the *Clack I*, give ſufficient aſſurance that *D* has Diſcharged and *Emptied* it ſelf into *L*, to within *eight Inches* of the *bottom*. And inaſmuch, as from the *top* of *D* to the *bottom* of its *Pipe H*, is con-

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tained about as much *Water* as will *repleniſh* L one Foot. So you may be certain *L* is repleniſhed one foot of courſe. Then you open the *Cock I*, and *refil D* immediately. So that here is a *conſtant* Motion, without fear or danger of Diſorder, or *Decay*: If you would at any time know if the *great Boyler L*, be more than half *Exhauſted*, turn the ſmall *Cock N*, whoſe *Pipe* will deliver *Water*, if the *Water* be above the *Level* of its *Bottom*, which is half way down the *Boyler*; if not, it will deliver Steam. So likewiſe will *G* ſhew you if you have *more* or *leſs* than eight Inches of *Water* in *D*, by which means nothing but a *ſtupid* and wilful Neglect, or *miſchievous*

Deſign, carried on for ſome hours, can any ways hurt the *Engine.* And if a *Maſter* is ſuſpicious of the Deſign of a *Servant* to do *Miſchief*, it is eaſily *diſcovered* by thoſe *Gauge Pipes*: For if he come when the *Engine* is at *work*, and find the Surface *C* of the *Water* in *L*, below the *bottom* of the *Gauge-Pipe N*; or the Water in *D* below the *bottom* of *G*, ſuch a *Servant* deſerves Correction, tho' three hours after that, the *working* on would not *Damage* or Exhauſt the *Boylers*: So that in a word, the *Clacks* being in all *Water-works*, always found the better, the *longer* they are uſed. And all the *Moving* parts of our *Engine*, being of like nature, the *Furnace* being made of *Sturbridge*, or *Windſor-Brick*, or Fire-ſtone ; I do not ſee it poſſible for the *Engine* to Decay in many Years : For the *Clacks*, *Boxes*, and *Miter-Pipe*, *Regulator* and *Cocks*, are all of *Braſs* ; and the *Veſſels* made of the beſt *hammered Copper*, of ſufficient thickneſs to ſuſtain the *Force* of the Working the *Engine*. In ſhort, the *Engine* is ſo naturally *Adapted* to *perform* what is required, that even thoſe of the moſt *ordinary* and meaneſt *Capacity*, may work it fo ſome *Years* without any *Injury*, *if not hired or imployed by ſome baſe Perſon on purpoſe to Deſtroy it.* For after the *Engine* is once *fixed*, and at *work*, I may modeſtly affirm that the *Adven-*

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turer, or Superviſor of the *Mine*, will be freed from that *perpetual Charge*, Expence and Trouble of Repairs, which all other *Engines* ever yet *imployed* in *Mines* for the *Raiſing* of *Water*, are continually *liable* unto.

CHAP. II.

Of the Uſes that this Engine may be applied unto.

IT may be ſuppoſed that there are few *People* among us ſo *ignorant*, but muſt neceſſarily know of what *value* the *Falls* of *Water* are in moſt Places, as being *applicable* to *Mills*; which are made after *various* Kinds and *Forms*, according to the *different* Genius and *Abilities* of the *Mill-right*; for *Mill-work* being in a manner infinitely *diverſified*; and had I leiſure to Comment thereon, and give you an Account, not only of the vaſt *variety*

riety that I have ſeen and *heard* of; but (when incouraged) what may yet be brought to *work* by a ſteady *Stream*, and the *Rotation* or Circular Motion of a *Water-wheel*, it would *ſwell* theſe Papers to a much larger *Volumn* than was at firſt deſigned, and *fruſtrate* my intended *Brevity*. I only juſt hint this to ſhew what Uſe this *Engine* may be put to in *working* of *Mills*, eſpecially where *Coals* are cheap.

I have only this to urge, That *Water* in its *Fall* from any determinate *Height*, has ſimply a *Force* anſwerable and *equal* to the *Force* that *Raiſes* it. So that an *Engine* which will *Raiſe* as much *Water* as *two Horſes*, working together at one time in ſuch a *work*, can do, and for which there muſt be conſtantly kept *ten* or *twelve* Horſes for doing the ſame. Then I ſay, ſuch an *Engine* will do the *work* or *labour* of *ten* or *twelve* Horſes; and whereas this *Engine* may be made *large* enough to do the *work* required in imploying *eight*, *ten*, *fifteen*, or *twenty* Horſes to be conſtantly maintained and kept for doiog *ſuch a work*; it will be improper to ſtint or *confine* its Uſes and Operation in reſpect of *Water-Mills*.

2. It may be of great Uſe for *Palaces*, for the Nobilities or Gentlemens *Houſes*: For by a *Ciſtern* on the *top* of a *Houſe*, you may with a great deal of *Eaſe*, and little Charge, *throw* what

Quantity of Water you have occaſion for to the *top* of any *Houſe* ; which Water in its fall, makes you what *ſorts* of *Fountains* you pleaſe, and ſupplys any *Room* in the *Houſe*. And it is of excellent *Uſe* in caſe of *Fire*, of which more hereafter.

3. Nothing can be more *fit* for ſerving Cities, and Towns *with water*, except a *Crank-work* by the *force* of a *River*. In the Compoſing ſuch ſort of *Engines*, I think no Perſon hath excelled the Ingenious Mr. *George Sorocold*. But where *they* are forced to Uſe *Horſes* , or any *other* ſtrength, I believe no Ingenious Perſon will deny this *Engine* to have the *Preference* in all *Reſpects*, being of more *Univerſal*

Uſe than any yet *Diſcovered* or Invented.

4. As for *Draining* Fens and *Marſhes*, &c. I ſuppoſe I need ſay no more than this, That that *Force* which will *Raiſe* great Quantities of *Water* a height of above 80 Foot, muſt neceſſarily *deliver* a much *greater* Quantity at a *leſſer* height. And that it is much *cheaper*, and every way *eaſier*, eſpecially where Coals are Water-borne, to *continue* the Diſcharge of any *Quantities* of Water by our *Engine*, than it can be done by any *Horſe-Engines* whatſoever.

5. I believe it may be made very *uſeful* to Ships, but I dare not meddle with that matter; and leave it to the Judgment of

thoſe who are the beſt Judges of Maritain Affairs.

6. For *Draining* of *Mines* and *Coal-Pits*, the Uſe of the *Engine* will ſufficiently *recommend* it ſelf, in raiſing *Water* ſo *eaſie* and *cheap*; and I do not doubt, but that in a few *years*, it will be a *means* of making our *Mining Trade*, which is no *ſmall part* of the *Wealth* of this *Kingdom*, *double*, if not *treble* to what it now is. And if ſuch vaſt Quantities of *Lead*, *Tin*, and *Coals* are now *yearly* exported, under the *Difficulties* of ſuch an *immenſe Charge* and *Pains* as the *Miners*, &c. are now at to Diſcharge *their water*; how *much more* may be hereafter *Exported*, when the *Charge* will be very much *leſſen'd* by the Uſe of

this *Engine*, every way fitted for the Uſe of Mines? For the far *greater* part of our *richeſt Mines* and *Coal-Pits*, are *liable* to *two* grand *Inconveniencies*, and thereby rendred *uſeleſs*; *viz.* The Eruption and Exceſs of *Subterranious* Waters, as not being worth the *Expence* of *Draining them* by the great *Charge* of *Horſes*, or *hand* Labour. Or ſecondly, Fatal *Damps*, by which *many* are ſtruck *blind*, *lame*, or *dead* in theſe *Subterraneous Cavities*, if the *Mine* is wanting of a due *Circulation* of Air. Now *both* theſe Inconveniencies *are* naturally *remedied* by the *work* of this *Engine* of raiſing *water* by the impellant Force of FIRE.

For the *Water.* Be the *Mine* never ſo *deep*, each *Engine* working it 60, 70, or 80 foot high, by applying or *ſetting* the *Engines one* over another, as ſhall be ſhew'd at large hereafter in the following Pages, you may by a ſufficient number of *Engines* keep the *bottom* of any *Mine dry*; and when once you know how large your *Feeder* or *Spring* is, it is very *eaſie* to know what ſiz'd *Engine*, or what number of *Engines* will do your Buſineſs.

The *Coals* uſed in this *Engine* is of as little value, as the *Coals* commonly burned on the *Mouths* of the *Coal-Pits* are: For an *Engine* of a three Inch-bore, or thereabout, *working* the Water up 60 *foot* high, requires a *Fire-place* of not above *twenty* Inches deep, and about *fourteen* or *fifteen* Inches wide, which will occaſion ſo ſmall a Conſumption, that in a Coal-Pit it is of no account, as we have Experienced. And in all parts of *England* where there are *Mines*; *Coals* are ſo *cheap*, that the Charge of them is not to be mentioned, when we conſider the vaſt quantity of *Water* raiſed, by the inconſiderable *value* of the *Coals* uſed and *burnt* in ſo ſmall a *Furnace*. What the quantity of Coals uſed for one Engine in a year is, cannot eaſily be aſcertained, becauſe of the different Nature of the ſeveral ſorts of Coals.

As for the Cure of *Damps* by this *Engine*, the Air perpetually crowding into the *Aſh-hole* and *Fire-place*, as it is natural for it to do, and with a moſt impetuous Force diſcharged with the *Smoak* at the top of the Chimney, the *contigious* Air is ſucceſſively following it; ſo that not only all *Steams* or Vapours whatſoever, that may or can *ariſe*, muſt naturally *force* its way through the *Fire*, and ſo be *diſcharged* at the top with the *Smoak*. But this Motion of the *Fire* will occaſion the *freſh Air* to deſcend from above, down all the *Pits*, and every *where* elſe in the *Mine*, but down the *Chimney*; provided you have a heading Drift, or Paſſage from all the Shafts, or Pits in the Work,to that place where the E*ngine* ſtands, whether the *Mouth* of the ſaid *Pit* and Chimney be *lower* or *higher* than the Mouths of any of the reſt of the *Pits* or *Shafts* in the ſame *Work*, it matters not; for here will be a perpetual *Circulation* of the *Air*, and with that *ſwiftneſs*, as is hardly to be *believed*. This I have tryed, and know to be true; ſo leave the Ingenious Miner to his own Judgment, Whether when all the Air is in a ſwift Motion, that any Stagnation of Air (which has always been adjudged the cauſe of *Damps*) can happen in any *Pit*.

CHAP.

CHAP. III.

The Manner of Fixing the Engine for Water-Mills, Palaces, and Gentlemens Seats, and Dreining Fens, and Supplying Houſes with Water in General.

1. FOR *Mills.* The *Engine* muſt be made and proportioned according to the Quantity of *Water*, required to *Drive* the *Mill* you would make Uſe of. Now ſuppoſe you would make a *Mill* on a plain place, where you will have only a *Pond*, and a ſmall *Spring*

of *Water* no bigger than a Quill; then you muſt build your *Mill-houſe* thirty ſix foot high, in which you may make what Motions, and what ſort of *Mills* you pleaſe. By the ſide of which Houſe without, may be placed your *Water-wheel* of thirty two, thirty three, or thirty four foot *Diameter*. For the height of either Houſe or Wheel, I would confine no Perſon too exactly, but I gueſs that a convenient height, and no more then what is common enough. Under the *Wheel* I would have a *Pond*, and on the top of the Houſe a *Ciſtern* of *Wood*, lined with *Lead*. The *Engine* may be fixed in any Corner of the Mill-Houſe, 20, 21, 22 feet or more from the Level of the Pond : There two *Boylers* muſt be *fixed*, as ſhewn you in the Draught for *fixing* the *Engine*; and round each of them it is convenient to have a Hoop of Iron, with ſtraps coming from them to reſt on the Brick-work, to ſupport and ſtrengthen them. Your *Clacks* and *Pipes* in the *Front* being ſupported by Wood, and the Veſſels ſtanding on *Pedeſtals* of Wood, it is convenient that the *Flew*, or *Chimney* be ſo contrived, as to draw very *ſharp*, and the Flew to *Circulate* round both the *Boylers*, ſo that you may loſe no part of your ſtrength.

2. For Palaces or the *Nobili-ies* or Gentlemen's *Houſes*, you may fix the *Engine* in any re-

mote or out-Room, whoſe *Floor* is not above twenty foot from the *Level* of your *Water*, and you may continue your Force-Pipe to the *top* of your *Houſe*, with a convenient *Ciſtern* to hold your *Water*. Into which lay the *Pipes* which may convey the *Water* as you want it, either for *Pleaſure* or Common Occaſions. This way of *Ciſterns* on the *top* of your *Houſes* or Palaces, would be of ſingular *Uſe* in caſe of *Fire*, as is ſaid before; for in every *Stair-Caſe* a Pipe may go down the Corner, or behind the Wainſcot, ſo as to be no *Blemiſh* even to the fineſt of *Stair-Caſes*. At every Floor there may be a *Turn-Cock* with a *Skrew*. At the utmoſt end, have likewiſe a ſmall *Leather-Pipe*, kept well oyled, in a Cup-board or Cavity in your Wall, which may not be ſeen, but on the opening ſome part of the Wainſcot; or ſuch other Contrivance as the Ingenious *Builder* ſhall think fit to make *uſe* of. This *Pipe* of *Leather* muſt be *long* enough to reach from the *Landing*-place or *Stair*-head, in all *Rooms* depending thereon. One end of this *Pipe* has a *Skrew* to fit the *Cock* in the other *Pipe*; and at the other end a *Pipe* like the Noſe of a pair of Bellows. So that wherever, tho' under a *Bed*, or the *remoteſt* part of any *Room* in the Houſe, the *Fire* breaks out, or is diſcovered, any Servant having *ſkrewed* the *Pipe* to the

Cock, *ſtops* the *Noſle* with his *Thumbs*, till he comes to the *place* where the *Fire* is, when taking away his Thumb, he by directing the *Noſle* to the *Fire*, immediately *extinguiſhes* it, which being liable to be inſtantly uſed, I think a *Houſe*, *Palace*, &c that has this Invention, may be ſaid to be morally out of Danger of being Deſtroyed, or ſo far injured, as *Whitehall* and *Kenſington* have been within a few years. This *Command* of *Water* muſt be allowed to be of vaſt advantage to any Houſe whatſoever. Where *Brewing*, *Waſhing*, &c. is uſed, The *Copper* ſtanding *high*, may be filled as eaſie as if it ſtood *low*, by which means, the hot *Liquor* may be contrived to go to all your *Coolers* , and other *Veſſels*, either by a *Cyphon*, Stop-Cock , *&c. without* the Hand-labour of *Pumping* or Bailing with *Buckets*. But more Conveniencies then we can at preſent foreſee, will be diſcovered in the *Uſe of this Engine*, *for Palaces*, *Houſes*, &c.

3. For *Fens*, and the like, it is convenient that theſe *Engines* be made very large : For at all ſmall *Hieghts*, a ſmall quantity of *Fire* will deliver *prodigious* Quantities of *Water*. For ſuppoſe we *Force* but thirty foot , and *ſuck* twenty foot, if the *Boyler* does but *fill* the Veſſels called *Receivers*, with *Steam* ſtrong enough to Counterpoiſe or Exceed the *Force* of the *Atmoſphere*, or Spring

of the Common Air, it will diſcharge them at ſo ſmall a Height as thirty foot *Force*, in a very *little* Time: And the *Steam* having very little *Force* or Spring, is immediately *Condenſed*, ſo that it will preſently *ſuck* full in one of the *Veſſels*, while the other is Diſcharged. Now inaſmuch as the *Fire*, being more or leſs, *adds nothing* to the Suction, I think ſuch *Lifts*, being ſeldom *above* thirty ſix foot, or *under* ſix foot, all the *Directions* farther *needful* for fixing the *Engine* for this *Uſe*, is in all Lifts under *twenty four* foot, to place your *Engine*, ſo as a little above your *Force-Clacks*, may be the place of the *Delivery* of your *Water* into a convenient Trough or Lander;

to be carried off at the moſt proper place for its Diſcharge. If it be any *Height* above *twenty four* foot, you have nothing to do but to continue the *Length* of your *Force-Pipe* to the *Height* required. It ought to have a Shed or Covering round it, and to be placed at the *loweſt* place of your *Fenn* or *Bogg*, as other *Engines* deſigned for that purpoſe commonly are.

As for fixing the *Engine* in *Ships*, when they may be thought probably uſeful, I queſtion not but we may find conveniency enough for fixing them.

In *Mines* and *Coal-Pits* the manner of *fixing* the *Engines* is this; Your *Pit* being ſunk, and a *Sump* or proper *Well* or bottom

Ciſtern, made to receive the *Water* coming from the ſeveral *Feeders* or Springs. Suppoſing an *Engine* carrying 3¼ Inch Bore , is to be fixed to deliver *Water* about ſeventy foot *high*, conſtant running a ſull Bore ; in ſuch Caſe you make a ſmall Room in your *Shaft* or *Pit* , which, together with your *Shaft* or *Pit* is nine foot ſquare every way. As for Example ; Suppoſe your Shaft ſix foot by four, take three foot out of one ſide, and five out of another Perpendicular nine foot, making a ſmall *Floor* or *Platform* of *Boards* over that part of the *Shaft* which goes down to your *Sump* or bottom *Ciſtern* , ſo you have a compleat Room big enough for your *Engine*, where ten or twelve People may ſtand on occaſion. This *Floor* may be about *eighteen* , nineteen , or *twenty* foot from the *Water*, at the loweſt you ever will draw the *Water* into the *Sump* or bottom *Ciſtern*. If your Ground be *looſe*, 'tis convenient to Line this *Room* with *Brick*; if *Rock*, it may ſupport it ſelf. But in this the *Miners* Judgment muſt direct him. That the *Engine* will ſtand beſt in the ſide of the *Pit*, where moſt is digged away, you may ſee in the ſecond Figure of the *Engine*, being fixed in a *Mine*. Your *Pipes*, &c. muſt be *fixed* with Cramps of *Iron*, *Wood*, or ſuch Materials as are convenient, to the ſide of the *Pit* or *Shaft*, ſo as to make it ſtand as *firm* as the very Shaft it ſelf. Your *Furnace* muſt be ſo contrived, that your *Flame* take a *turn* or two *round* each of the *Boylers*, which any *Bricklayer*, uſed to *Furnaces*, can do; it being performed by running a row of Bricks round them both like a Skrew or Worm; which being *contigious* to the *Wall* of the *Furnaces*, and the *Boylers*, makes it as it were a Worm *Funnel* round them both; from whence you may continue your *Chimney*, to the top of your Work, which you faſten to the ſides of your *Shafts* in the *Corners* as you pleaſe, either with Iron or Wood, or both, according to the nature of the Ground. And wherever you make a ſudden Bent or Nook near a Right Angle in the *Chimney*, have a looſe *Brick* or *Stone*, to take out the *Soot*, if any ſhould ſettle in ſuch place, which in long working it may do.

SEVE-

SEVERAL
OBJECTIONS
Againſt the
Working this Engine
ANSWERED,
IN A
DIALOGUE
BETWEEN A
Miner and the *Author*.

Miner. SIR, Having been ſome time concerned in the *Engines* now *uſed* for drawing *Water* out of our *Mines*, and hearing ſo much Talk of *this* wonderful *Invention* of yours of Raiſing *Water* by *Fire*, I was very deſirous to Enter into ſome Diſcourſe with you, concerning the Nature, Uſe, and Application of your *Engine*, ſo ſtrangely *differing* from *all* other *Engines* ever yet *Invented* for our Works, and which you poſitively affirm will every way *tend* ſo much to our *Advantage* in the *Uſe* of them; and I do not doubt of meeting with that Plainneſs, Freedom, and good Humour, that your Diſcourſe is generally accompanied with. And with the ſame *Freedom* Reſolve me in *ſuch Queſtions* as the General Senſe of us *Miners*, may *Naturally* propoſe to *Object* againſt the Uſe of your *Engine*, eſpecially ſuch of us, as are yet *Ignorant* of its *Uſe* and Operation, who are more capable to Judge of *Fact*, than of the *Nature* and Power of that *Force* which Raiſes your *Water.*

Author. Sir, I am extreamly Obliged to you for your Freedom; and ſhall readily Imbrace all Opportunities to Inform and *Explain* to you the *true* Uſe and *Nature* of my *Engine.* And therefore deſire you with all imaginable Freedom to proceed, and ask what Queſtions you pleaſe, either as to your own *Thoughts*, as well as what has been *ſuggeſted* to you by *Others*. And you may be aſſured of a *plain* and canded *Anſwer* to all your Objections.

Miner. Then Sir, which way will you go to *work* with your *Engine* to clear an *Old* Work full of *Water*.

Author. Why Sir, to deal plainly with you, if your *Shafts* are, or may be cut *ſtreight*, your *Tub-Engines*, or Chain *Pumps*, may draw forth the *Water*. And the Charge in that reſpect is not to be accounted for; becauſe no *Mine* would be thrown up or *neglected*, but on account of the Feeders or *Springs*, which being certain, and *conſtantly* to be carried off Winter and Summer. The proſpect of being likely to ſucceed, makes your *Mine* worth working or *emptying*, within twenty foot of the Bottom, if ever they were worth ſinking, though you *work* or *Drain* by the common way of *Tubs* or *Chain-Pumps*. And could the conſtant Charge of thoſe *Engines* be afforded, *Numbers* of them will *Empty* and keep under any *Work*; but it is the conſtant *Charge* of carrying off what the *Springs* bring in, is the chief thing to be *conſidered* in the Buſineſs of *Mines*, which conſtant Charge is what we leſſen very much by this *Engine* of mine.

Miner. What ſignifies your *Engine* then, Sir, if it be not capable of *Sinking* or Forking an *Old Mine*.

Author. Hold my good Friend, a little patience; I have dealt plainly and impartially with you about the *Uſe* of your Old *Engines*:

gines : And for my *Engine* , it will clear an *Old work* , if full of *water* , as readily as your *Tub-Gins* or *Chain-Pumps*, provided the Shafts are good. The Method I propoſe to *Clear* an *Old Mine*, if *ſixty* foot deep, and full of *water*, the *Feeders* not above *two* Inch-bore, which is done at a very ſmall Charge after this manner; *viz.* I fix my *Engine* on the top of the *Mine*, and only *ſuck* and deliver a 3¼ Inch-bore; as ſoon as we have *ſunk* the *Water* as far as our *Suction* will go, which will be ſome 22, 24, or 26 foot *deep* below the Surface. There I make a *Room* fit to receive another *Engine* , which I *fix* with his *Force-Pipe* to go up to the top of the *Pit* ;

and when I have *ſunk* about 24, or 26 foot more: Then I fix a *ſmaller Engine* of *two* Inches-bore, which *ſucking* twenty, and *forcing* forty, does your work, and keeps all ſafe: Or let your *ſmall Engine* be kept at Work, while you remove the *larger Engine* from the top to the middle Station, and then you will have Occaſion for no more than *two* Engines; the *greateſt* of which may be removed as ſoon as the *ſmaller* is *fixed* in the loweſt or proper Station. And that you may be convinced of my Impartiality, it is my Opinion, That in gaining an *Old Work*, or ſinking a *New One*, you uſe your *Old* Engines of *Tub* or *Chain-Pumps*: This *Engine* of mine being moſt proper

per, when you are come fairly to the *Bottom* either of the *Oar* or *Coal*: For then, if you have but one *Lift*, one *Station* or *Engine*-Room will be ſufficient. And by having two *Sumps* or Bottom *Ciſterns*, your *Water* may in ſome meaſure *ſettle* in *one* of them, in its paſſage to the *other*. So that the *Miners* working tolerable clean, and ſuffering as little dead or looſe *Coal* or *Oar*, as is poſſible, to mix with the *Water*, you may have the *Water* to draw only a little *diſcoloured*; for you know as well as I, that generally the *Water* coming from Mines or Coal-Pits, while they work by the *Gins* now in uſe, is almoſt *clear* Water.

Miner. Sir, I thank you for your Candor in relation to the clearing of an *Old Work*. But ſuppoſing that our *Water* ariſes thick and *muddy*, which you know will ſome times happen, what ſhall we do with your *Engine* then?

Author. What you ſay Sir, I know to be very true, that ſome times you have thick *muddy* Gravel and naſty *water*. To prevent which from coming in to, or offending our *Pipes*, we have a *Frame* of Board made full of *Holes* round about the *Bottom* of our *Pipe*, that receives the Water; for *Sluge* or fine *Dirt*, it will do my Engine no Injury. Indeed the *clearer* our *Water* is in our *Boylers*, the *better* it is for our *Work*; but for our *Receivers* and their *Clacks*, you may *clear* them as you Work it, from *Stones* , *Coal* , *Oar*, or any other *Anoyance* , though hung in the very *Clack*; for by *emptying* of one or both the *Receivers* of their *water*, you cauſe the *Motion*, either of *Suction* or Force , immediately to be ſo ſtrong , as to *clear* and *blow* out all before it to the *Top* of the *Pit*. Inſomuch that I have found Filings of *Copper* , large Bits of *Metal*, conſiderable Quantities of *Coal* and *Stone* , delivered and thrown up with the Water out of my Engine above *ſixty* foot high. However, *clear* Water is preferrable before the *dirty* Water in the *Work* of mine *Engine*.

Miner. But dear Sir, if 60, 70 or 80 foot be *the* Determinate *Height* for Raiſing of *Water* by your E*ngine*, How ſhall we Uſe your E*ngine* in a *Mine* or *Pit*, that requires *water* to be raiſed three times 80 foot, as you know ſome of our Works do.

Author. I heartly thank you Sir, for this laſt Propoſal, becauſe I have now an Opportunity to acquaint you, That the *Force* uſed in my *Engine* is in a manner *Infinite* and unlimitted, and will *Raiſe* your *Water* 500 or 1000 foot high, were any Pit ſo deep; and that you could *find us* a way to procure *Strength* enough to *Support* ſuch an Immenſe *Weight*, as a Pillar of Water a thouſand foot high muſt certainly produce.

However, to give you an *Anſwer*, I muſt intreat you to give my *Engine* as kind Entertainment and *fair Quarter*, as you do to *your* Engines now in *Uſe* : For I am ſure you are not ignorant of a Cuſtom uſed in very *deep Mines*, (in ſeveral parts of *England*) of Raiſing their *Water* by ſeveral Lifts, from *Ciſtern* to *Ciſtern*, to a very great Height ; although ſome of their *Lifts* may not be above *twelve*, *ſixteen*, or *twenty* foot a Lift at the moſt. And ſuppoſe that your *Engine* now in *Uſe* at *twenty* foot the Lift, and my *Engine* at *ſixty*, *ſeventy* , or *eighty* foot, for at any of theſe *Lifts* we Raiſe a *full Bore of water* with much eaſe. Then one *Lift* of my *Engine* at *ſixty* foot, anſwers to three *Lifts* of your Engines at *twenty* foot, and alſo to *four* of your Lifts at *eighty* foot, *&c.* which you may pleaſe to take for a ſufficient Anſwer to your laſt Objection. I have known in *Cornwall* a Work with three *Lifts*, of about *eighteen* foot each Lift, and carrying a $3\frac{1}{4}$ Inch-bore, that coſt *forty two ſhillings per diem*, reckoning *twenty four* hours the day, for Labour, beſides Ware and Tare of *Engines*; each *Pump* having *four* Men working *eight* hours at *fourteen pence* a Man, and the *Men* obliged to *Reſt* at leaſt $\frac{1}{3}$ part of that time.

Miner. You have Sir, hitherto *given* me undeniable *Anſwers* to my former *Objections*, for which

I

I thank you; but I fancy I ſhall puzzle you, when I ask you how you will Manage your *Engine* to *draw* up our *Water?* where the *Shafts* are not *Direct*, but *turn* and *wind* to and fro.

Author. Sir, This laſt Queſtion is ſo far from being any hardſhip put upon my *Engine*, that no *Engine* ever yet invented was ſo naturally *adapted* to Work in theſe *crooked* Shafts, as mine is: For let the *Windings* or Turnings of the *Shafts* be what they will, *the* perpendicular *weight* of *Water* is all that my *Engine* has to account for, and is the *ſame* as if it made the Figure of a *Diſtiller's Worm*, and went through the ſtraighteſt Pipe imaginable, except a little inconſiderable *Friction* of the *Water* againſt the ſide of the *Pipe* that is crooked, more than is in the *ſtraight* Pipe; which is ſo *ſmall* a matter, that a very *nice Judge* would hardly be *able* to diſtinguiſh, whether the *crooked* or ſtraight *Pipe* carried off moſt *water* in the working. For the *Flew* that carries the *Smoak*, Experience ſufficiently inſtructs you, that you may turn and *wind* it any way you pleaſe, and that ſuch *windings* in their *Drawing* moſt *Air*, do rather *improve* than prejudice your *Flew*, as any one experienced in Building of *Furnaces*, can inform you.

Miner. Well Sir, I find that our *crooked* Shafts will not any way incommode your *Engine*:

But what think you of Accommodating your Engine to the Service of the *Lead-Mines*, whoſe *Shafts* are many times ſo *narrow*, that it will be very *difficult* to get your *Engine* down.

Author. I perceive Sir, you are yet much a Stranger to the *Nature* of my *Engine*, which is ſo *furniſhed* with Braſs *Skrews*, and as *ſtrong* as the very Metal it ſelf, that you may *take* it to *pieces*, and with eaſe put it *together* again, fit to work in a *few* hours time; and ſo contrived, that where a *Man* can well go *down*, there I can put down my *Engine*, in ſeveral pieces, and fix them below; for the greateſt *Boyler* belonging to my *Engine*, is between *twenty four* and *thirty*

Inches *Diameter*, and may, if occaſion require, be made yet much *narrower* and *deeper*. And that if it be difficult to bring the *Shaft* of the *Mine* to *fit* my Engine, I can with much *eaſe* make my *Engine to fit* the Shaft of any Mine.

Miner. But will not theſe *Braſs Valves* that you ſpeak of in your *Engine*, ſpeedily *ware* out and ſtop your Work ?

Author. No: They cannot fail me ; becauſe Experience ſhews us, That *Braſs Valves* improve, rather then grow worſe, by *twenty* or *thirty* years Uſe in any *Force-work*, where conſtantly worked, and where they *Riſe* and *Fall* twenty times *oftner* than my Valves will do.

Miner. But what think you, Sir, if you ſhould meet with ſuch *Corroſive* Water in ſome of our *Mines*, as will in a little time *eat* through your *Copper* Veſſels.

Author. Truly Sir, this Queſtion does a little ſtartle me, becauſe I never expected to meet any *Water* of ſuch a *Corroſive* quality in any Mine: And could I find out a *Mine*, whoſe *water* abounds with ſuch *Acid Particles*, as to Deſtroy or Injure the *Copper* Veſſels of my *Engine*, I would *Drain* that Mine for nothing but the *water* I ſhall *take up*; becauſe the *water* would be more *valuable* than any *Oar* (I believe) in *England*. And were there even a *tenth part* of *Aqua*

Fortis to *nine* Tenths of Common *water*, which is impoſſible to ſuppoſe it ſhould be; I ſay, ſuch a *water* could have no Effect on the *Coppers*, were that *water* to lodge ſome time in the *Copper* Veſſels, much leſs in paſſing through *them* with that *Celerity* and Rapid motion that always acpanies it.

Miner. But Sir, will not ſuch a *Continual Fire*, as muſt be kept under your Boylers, *burn* them out in *two* or *thre* Months time, and *ſpoil* the Work of your *Engine.*

Author. I can aſſure you they will not *Decay* in ſome *years*, (unleſs ſome *Fellow* be hired or imployed on purpoſe to do it. And ſhould any *Villain* be imployed to *burn*, *break*, or *De-*

ſtroy any of the Engines now uſed in your Works for Raiſing of Water, we are then on the ſame Level with you in that point. But I will give you one *Reaſon* why my *Engines* will not eaſily *Decay*, and I am ſure that will go further with you than all the Affirmation I can make. For firſt of all, Although a *white* Heat will *melt* Copper, and a *red* Heat, and ſudden *cooling* it again, will *Scale* the *Copper*, yet ſuch a Heat as is poſſible for it to have or ſuffer while *Water* is in the *Boyler*, can have no ill *Effect*, or cauſe any *Alteration* in our *Copper*. A Friend of mine has *Coppers* uſed in *Sugar* Boyling of *twenty* years ſtanding. They may be a ſmall matter *worn* with cleaning on the *Inſide*, whereas on the *Outſide* there does not appear the *leaſt* viſible *Decay*: For as ſoon as the *Fire* has thrown a thin Coat of *Soot* on the Outſide of the *Boyler*, the *Flame* has no other Effect on it, than to cauſe the *Water* in it to Boyl.

Miner. But we have *often* Combuſtable *Vapours* in our Mines, which taking *Fire* from the *Candles* uſed there, do by a ſudden *Explotion* Deſtroy both the *Mine*, and the Miner; and therefore I am afraid that the *Fire* uſed in your *Engine* will be very *Dangerous*, and apt to *Kindle* thoſe Combuſtables more than our Candles.

Author. To Anſwer this *Objection*, I will deſire leave to give you my Notion of thoſe *Combuſtables*, which, in ſhort is this: That when your *Miners* come into a cloſe Place, where there is no *Circulation* of Air to carry off the *Effluvia*, or Attoms conſtantly Riſing like *fine Duſt* in a Powder-Mill, *they* by knocking and *working* do Increaſe to be very numerous, like to thoſe *looſe* Particles in a *Powder-Mill.* But it is the *work* of ſome *time*, for thoſe *Vapours* to come to *Perfection*; for I have heard ſeveral Experienced *Miners* ſay, That it is common to avoid the *Danger* of thoſe *Vapours*, by Retiring as ſoon as they ſee the *Flame* of their Candles *burn* longer than ordinary; which may be diſcerned ſome times long before the *Air* is *thick* enough of this Combuſtable *Matter*, to take *Fire* at once, and like Gun-powder to *Deſtroy all.* I did hear one ſay, That from an *Inch and half*, once the *Flame* of his *Candle* did gradually increaſe to *two foot* long, and yet he eſcaped. Which makes it very plain, That *Stagnation* of Air is the ſole *Cauſe* of this Inconvenience in *Mines*, which may be totally prevented by a *Pipe* going from the *Aſh-Pit* of our *Furnace*, to any part of the *Mine* liable to *Stagnation.* For the *Air* will preſs, with great *Violence*, through the Pipe into the *Fire*, before the Combuſtable

Matter can be ready to do any Hurt, and *Paſſing* through the *Fire*, make way for *freſh Air* to Deſcend in the Room of it. So that our *Fire*, inſtead of blowing up of your Works, is the beſt *Means* that can be uſed to prevent ſo *Fatal* an Accident; and will likewiſe carry off all *unwholeſom Vapours*, *Damps*, or *Steams* which may proceed from Corruption of Air, by Stagnations, or Vapours ariſing from any Poyſonous Earth, or Mineral.

Miner. This Notion of yours carries Reaſon and Demonſtration along with it, which pleaſes me wonderfully. But Sir, Is not your Price too great for theſe *Engines* of yours?

Author. By what I ſhall offer to you, as to my price, I am ſure to have you a *Friend* to me and my *Engine* ſor ever. For I muſt tell you, that I would never have ſent my Engine into the World, if it would not raiſe your *Water* with more *Eaſe* and Conveniency to you and your Servants, and alſo much *Cheaper* than any other Engine ever uſed in your *Works*, without which I could never propoſe any *Advantage* to my ſelf by it. And to Convince you of the Truth of my *Aſſertion*, I dare undertake the *Engine* ſhall Raiſe you as much *Water* for *Eight* pence, as will coſt you a *ſhilling* to Raiſe the like with your *Old* Engines in Coal-Pits. By this one Article the Miner will *ſave* one *third* part of his former *Charge*, which is Thirty three pounds ſix ſhillings and eight pence ſaved out of every Hundred pound. A brave *Eſtate* gained in one Year out of ſuch *Great* Works, where *Three*, *Six*, or it may be *Eight* thouſand pounds *per Annum* is Expended for clearing their *Mines* of *Water* only, beſides the Charge and Repair of *Gins*, *Engines*, *Horſes*, &c. I hope you will not now Account my *Engines dear* under ſuch Conditions as I now offer ; But if I ſhould with you ſuppoſe my *Engine* proportionable *Dear*, or as Dear as the *Engines* you now Uſe for *Drawing* up your *Water*, which is impoſſible, my *Engine* will be preferrabel before yours in many reſpects, inſomuch as mine prevents your *Damps* and the Evil Effect of them: And as it will be my Intereſt to allow thoſe that *firſt* ſet my *Engine* at Work conſiderable *Advntages*; ſo I hope I may aſſure my ſelf of due Incouragement from the Ingenious, who are ever ſtudious to promote all Inventions uſeful and beneficial to the Publick; for they muſt conclude, that an *Engine* which for ſome time has daily imployed the beſt Artificers to work on it, was not to be brought forth in one day: And to bring it to that Perfection you now find it, muſt have coſt me and my Friends, not a little Money, to make the Workmen capable of their Work with that Certainty and Exactneſs they now do. And for Working the *Engine*, any *Perſon* may have his Servant taught it, it being to be learnt in a very ſhort time by one of an Ordinary Capacity.

Miner. But there are People who pretend to do great things in the Improvement of *Engines* to work by *Hand* or *Horſes*, the Hope and Expectation of which has hindred ſome of Us in our Work, and tired others, ſo as to make them out of love with all *Engines*, and almoſt with the Trade of Mining. And though I wiſh the contrary, I fear this may prove ſome hinderance to the promoting your Intereſt.

Author. True, Sir, I own that

Time out of Mind there have been Mountebanks, and *Impoſtors* in all Faculties, who *pretend* to *Great* Things, but do *perform* Nothing effectually. And it would be hard if that ſhould be drawn into Conſequence, That becauſe ſome are Knaves, therefore none are Honeſt. I know the Notions of the *Perpetual Motion*, or Self-moving Engine, and many ſuch like Whims are *pretended* to by *Deſigning Men*, and believed by Ignorant Ones: But the Judicious Man, who conſiders the *Laws of Motion*, knows it is an Infallible Rule, That whatſoever *Matter* is to be *removed upward*, muſt have a *Force* ſuperiour to the *weight* to be *lifted* up. If its *Motion* be required as *ſwift* as the *Motion* of the *Moving Cauſe* ; if *ſlower*, proportionably *leſs* ſtrength will do ; if *ſwifter*, then the *Moving Cauſe*, as Mens Hands, Horſes, or Dead Weight, then muſt the Strength of the Moving Cauſe be Increaſed proportionably, or no Motion can be produced. And the Experience of Ages ſhows us this, to be a moſt *ſure Rule*, allowing for *Friction*, which is *larger*, the more *Wheels* or Parts an *Engine* conſiſteth of ; and of Conſequence, the *fewer* Parts or *Wheels* an *Engine* conſiſteth of, the eaſier it Works : So that by barely looking on a *Pump*, if it has more Parts or *Wheels* then the Common *Crank*-

work, you may conclude it worſe; if a *Chain*-work or *Tub*-work the ſame. So that all that can be *Expected*, is to make thoſe *go Eaſier* then they are *now* made to go by Ingenious Workmen, expert in making them. And if you try how *ſmall* a Matter will *move* thoſe *Engines*, when not *Loaded* with *Water*, you will find the *Friction* ſo ſmall, as not worth any *mending*, could it be done, eſpecially the *Tub-Gin*, whoſe *Friction* increaſes the leaſt in being Loaded of any; but the others are vaſtly encreaſed by the *Leathers* of their *Suckers* being forced broader, and *Rubbing* with much greater *Force* againſt the *Barrel* they work in, according to the

Height the Pipes are raiſed.

And I hope, when it is conſidered how far this *Engine* of *Mine* differs from the bare *Pretenſions* of Ignorant or *Deſigning* Men; and that any Perſons may ſee what my *Engine* will perform, before they Contract for it; there will be found no Ground for the leaſt Suſpicion in any Perſon concerned to Imploy them in *Mines*: But to the contrary, afford us a Generous Incouragement, in a Buſineſs ſo conduſive to the Increaſing the Mining Trade, and thereby Inrich themſelves and the Nation, and Increaſe the King's Revenue.

I could heartily wiſh all *Miners*,

ners, for their own as well as their Countries Intereſt, were good *Mechanicks*, and truly underſtood the *Nature*, Uſe, and Application of all *kinds* of *Engines*; for I am ſure thoſe that do, will be my beſt Friends, without Expecting that *Horſes*, or *Men*, or any other *Strength* can or will do more then what *Nature* and the *Laws of Motion* has allow'd them.

BR. MUS.

THE END.

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